DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
JAPAN DISTRICT

FINAL REPORT

FY86 OMA PROJECT, ENERGY SURVEY OF DESIGNATED U.S. ARMY GARRISON HONSHU FACILITIES, ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

EXECUTIVE SUMMARY

JUNE 1989

PREPARED BY:
DANIEL, MANN, JOHNSON & MENDENHALL
TOKYO DIVISION

DEPARTMENT OF THE ARMY
JAPAN DISTRICT CORPS OF ENGINEERS
APO SAN FRANCISCO 96343-0061

JAPAN
ESOS N92 FY86

CEPOJ-ED-M (410-10a)

9 June 1989

MEMORANDUM FOR Commander, U.S. Army Corps of Engineers ATTN: CEEC-EE (Mr. Joe McCarty), Washington, D.C. 20314 (one copy)

DA Huntsville Division, Corps of Engineers, P.O. Box 1600, ATTN: CEHND-PM (Mr. Philip Brown), Huntsville, AL 35807-4301 (three copies)

HQ DA, ATTN: DALO-LEP, New Cumberland, PA 17070-5007 (one copy)

SUBJECT: FY86 Energy Survey of Designated U.S. Army Garrison, Honshu Facilities, Energy Engineering Analysis Program (EEAP)

1. The Architect-Engineer (A-E) firm of Daniel, Mann, Johnson and Mendenhall (DMJM), made a formal presentation of the subject project which was followed by a review conference on 15 May 1989.

2. Forwarded herewith are a summary of items discussed at the review conference, annotated review comments, and replacement pages of the documents listed below which comprise the final submittal for this project.

a. Executive Summary.
b. Main Report.
c. Appendix A (Scope of Work).
d. Appendix B1 (Energy Conservation Opportunity (ECO)).
e. Appendix B2 (ECO Life Cycle Analysis).
f. Appendix B3 Volumes 1 and 2 (Energy Monitoring and Control Systems (EMCS) Calculations).
g. Appendix B4 (EMCS Life Cycle Cost Analysis).
h. Appendix D (Documentation)

Note: Appendix C was submitted at the prefinal submittal to be retained

3. This submittal completes action on the subject project. POC for administrative purposes is Mr. Harry Murabayashi, Project Engineer, at AV233-4119/3469.

FOR THE COMMANDER:

Glenn T. Arakaki

Encl

GLENN T. ARAKAKI
Chief, Military Branch

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited.
Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering

EXECUTIVE SUMMARY

TABLE OF CONTENTS

CHARTS

FIGURES

TABLES

EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 GENERAL.

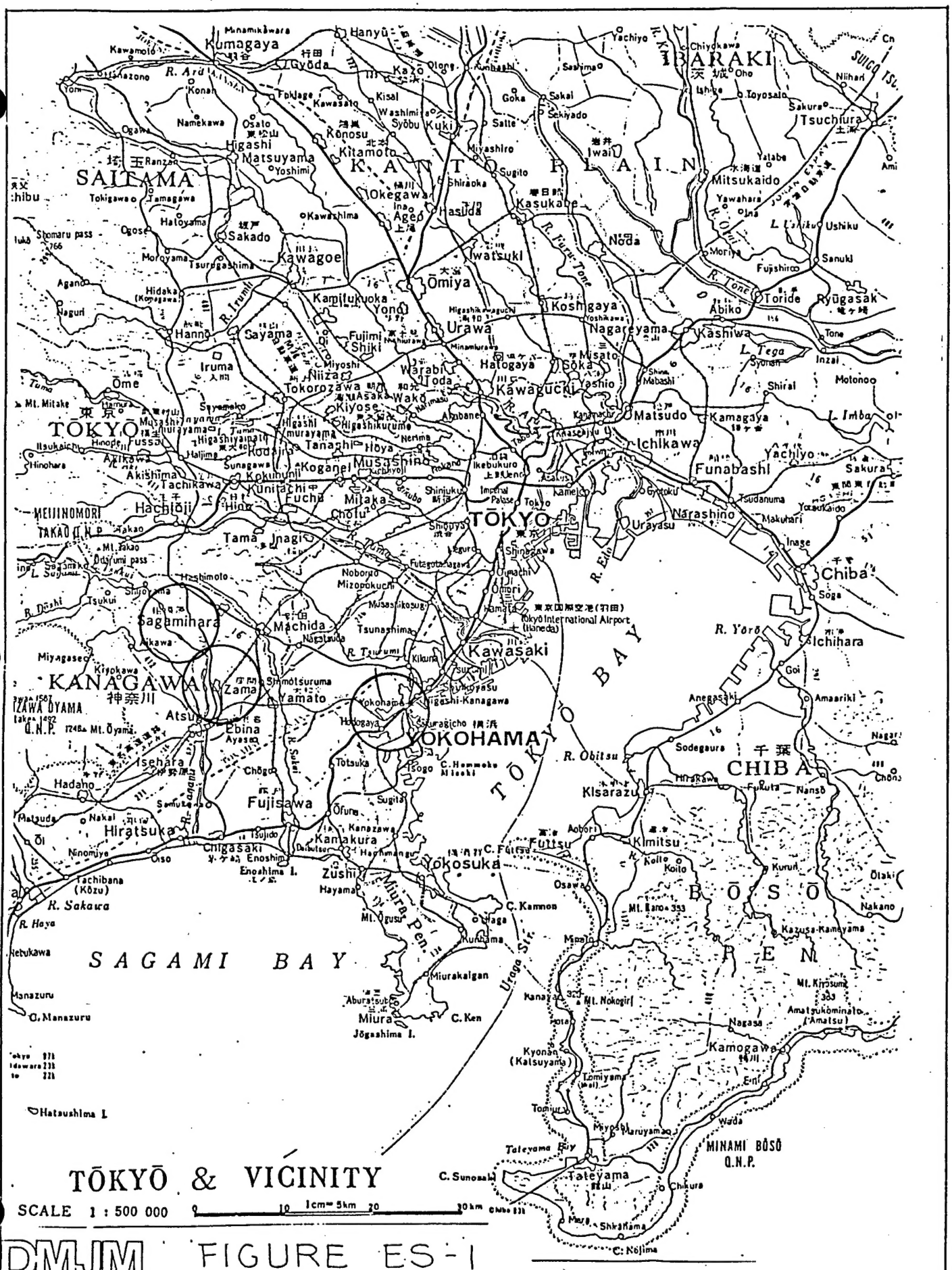
This document provides the Executive Summary of the Energy Savings Opportunity Survey (ESOS) and Energy Monitoring and Control System (EMCS) Feasibility Study of Designated U.S. Army Garrison, Honshu Facilities, for Camp Zama, Japan prepared under Contract No. DACA79-86-C-0091 between the U.S. Army Engineer District, Japan and the Architect-Engineering firm of Daniel, Mann, Johnson, and Mendenhall, Sagami Facility, Japan. This project has been executed as a part of the Department of the Army's FY86 Energy Engineering Analysis Program (EEAP).

1.2 OBJECTIVE.

The overall objective of this project is to perform a complete energy audit and analysis of designated facilities in order to identify all Energy Conservation Opportunities (ECOs), to evaluate ECOs from previous studies which have not been accomplished and to perform a feasibility study for the installation of an EMCS. Camp Zama and the Sagamihara Dependent Housing Area (SDHA) installations are located as shown in Figure ES-1 (Tokyo and Vicinity Map). Specific locations of the designated facilities at Camp Zama and the Sagamihara Dependent Housing Area are as shown in Figures ES-2 and ES-3, (Base Map - Camp Zama and Information Map Sagamihara Dependent Housing Area).

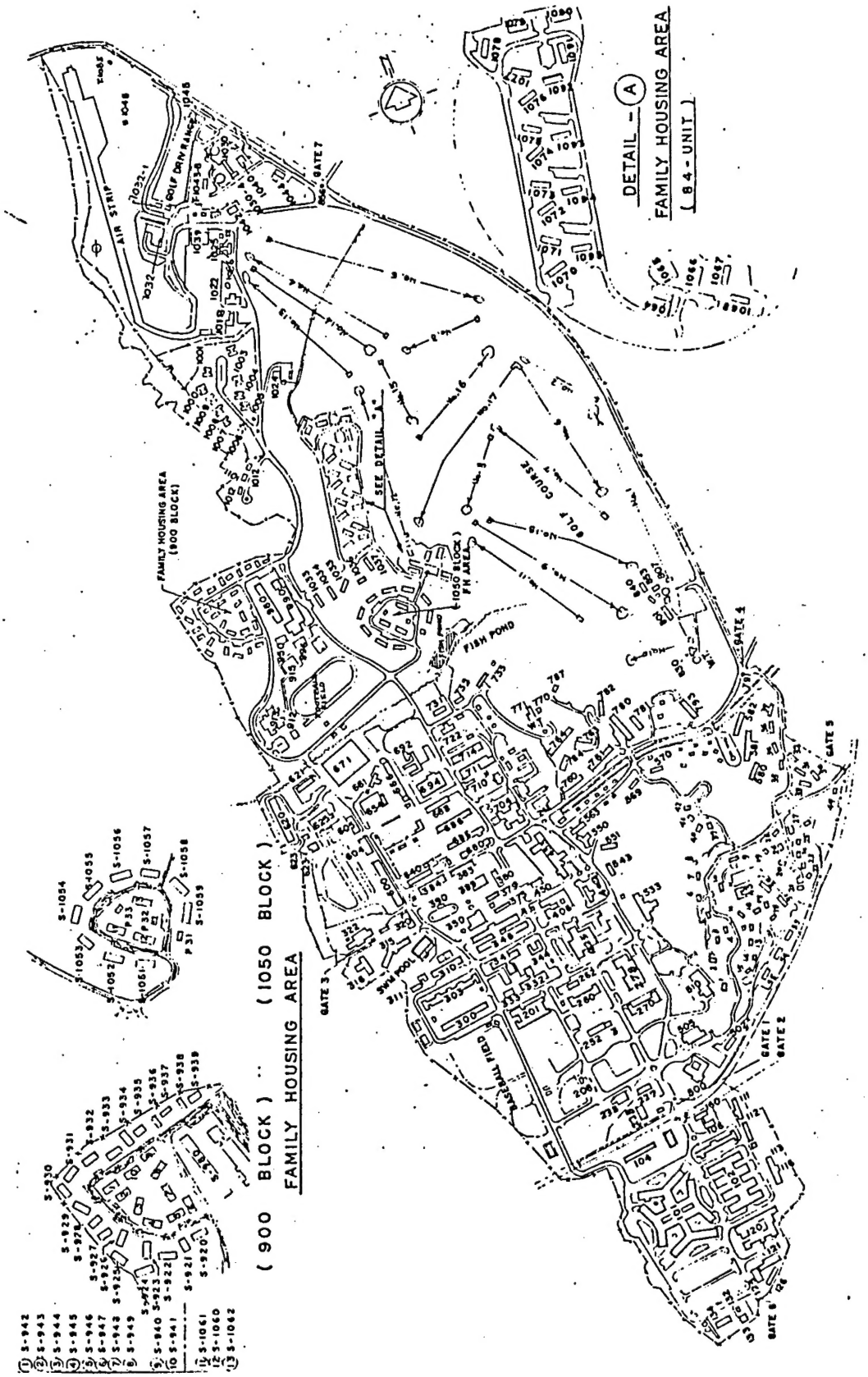
1.3 GUIDELINES

The "Energy Conservation Investment Program (ECIP) Guidance", described in letter DAEN-MPO-U of 10 August 1982 and subsequent revisions in letters DAEN-ZCF-U of 4 March 1985 and 11 June 1986 established criteria for ECIP projects. This guidance was used to perform an economic analysis of each Energy Conservation Opportunity (ECO). Construction cost escalation was calculated using the guidelines contained in AR 415-17 and the latest Tri-Service MCP Index. The survey and analysis of the potential EMCS was performed in accordance with guidance contained in the "Preliminary Survey and Feasibility Study for Energy Monitoring and Control Systems", HNDSP-84-076-ED-ME dated January 1984 and "Energy Monitoring and Control Systems", TM-5-812-2 (draft) dated February 1988. The energy savings for the EMCS portion were calculated using the criteria contained in "Standardized EMCS Energy Savings Calculations", NCEL CR82.030 dated September 1982. The "Scope of Work, FY86 OMA Project, Energy Survey of Designated U.S. Army Garrison, Honshu Facilities, Energy Engineering Analysis Program (EEAP)", dated 9 April 1986 and revised 15 and 28 May 1986, identifies



DMJM FIGURE ES-1

	JOB NO.	SHEET NO.
	DESIGNED BY:	DATE

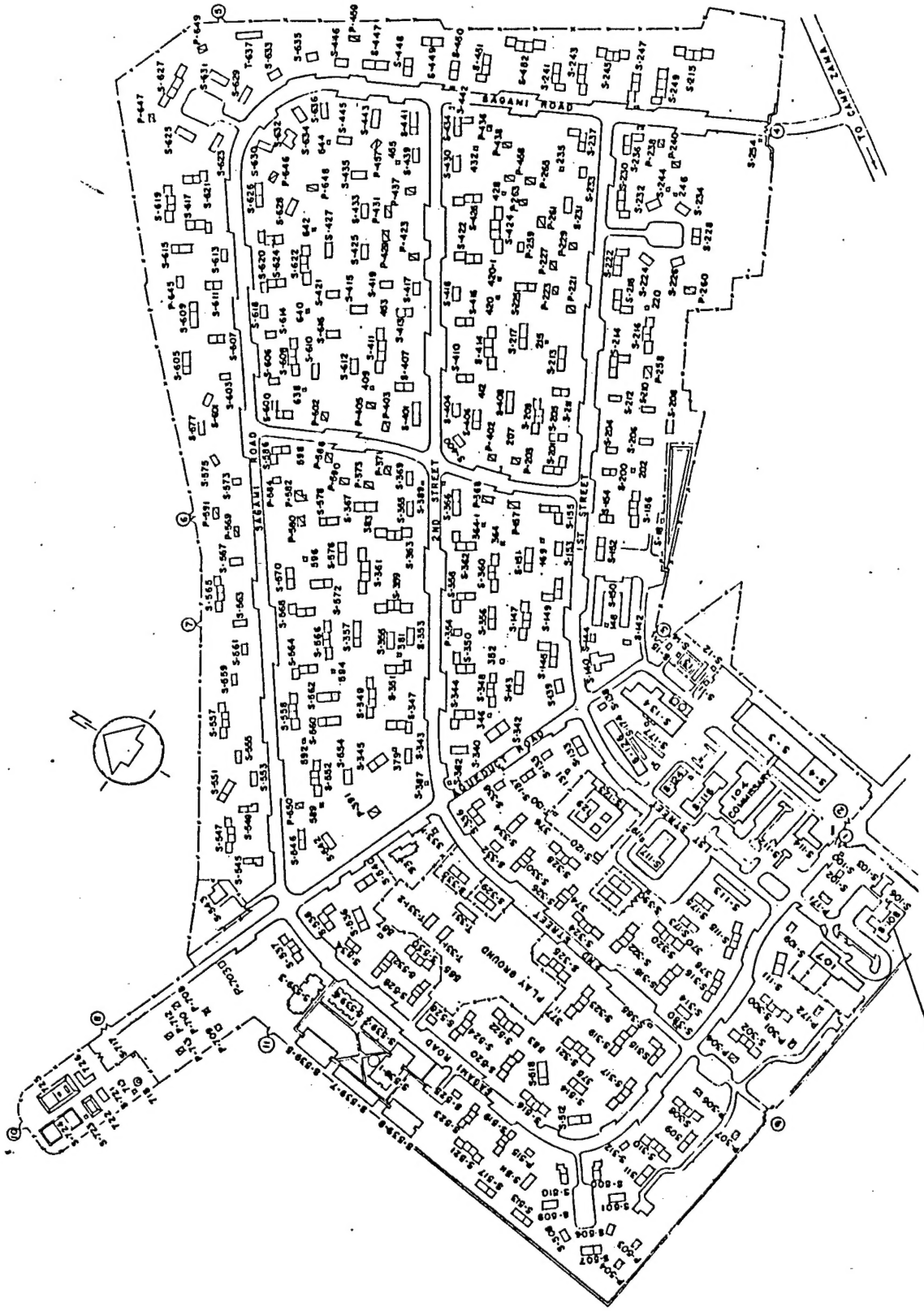


INFORMATION MAP
CAMP ZAMA
(FAC 30791)

FIGURE ES-2

DMJM

	JOB NO.	SHEET NO.
	DESIGNED BY:	DATE



INFORMATION MAP
SAGAMIHARA D H. AREA

FIGURE ES-3

DMJM

the general guidelines for completing the study and the specifics of the analyses and feasibility study to be performed. Because it was used extensively in performing this study, it is summarized below.

- Perform a complete audit and analysis of designated facilities.
- Identify all Energy Conservation Opportunities (ECOs) including low cost/no cost ECOs and perform complete evaluations of each.
- Prepare programming documentation for ECIP projects and implementation documentation for all justifiable ECOs.
- List and prioritize all recommended ECOs.
- Prepare a comprehensive report which will document the work accomplished, the results and the recommendations.
- Evaluate previously recommended but not implemented ECIP projects.
- Perform a study of designated facilities and electrical, mechanical and utility distribution systems to determine the feasibility of an EMCS for these facilities and systems.

1.4 STUDY METHODOLOGY.

This study was divided into two phases. Phase I involved data gathering, field surveys, identification of Energy Conservation Opportunities (ECOs), and preliminary ECO analyses as well as the feasibility of installing an EMCS. Phase II includes all final energy and economic analyses, categorization of projects for funding consideration, preparation of programming documents, and preparation of the Final Report. The Final Report will present all methods, results, and recommendations of this study. This Executive Summary specifically addresses the study results pertaining to the completion of Phases I and II of the study.

2.0 BUILDING DATA.

2.1 EEAP PORTION.

This study included the audit and analysis of four buildings at Camp Zama and SDHA with a total floor area of 50,869 square feet. These buildings are listed in Table ES-1 which also provides their location,

category code, current use, total floor area and usable area.

TABLE ES-1
BUILDING DATA

BLDG. NO.	LOCATION	CAT. CODE	CURRENT USE	TOTAL FLOOR AREA (SF)	TOTAL USABLE AREA (SF)
P-1024-1	Camp Zama	821 15	*REFUSE INCINERATOR	2,121	1,605
P-912	Camp Zama	730 49	DEP. HIGH SCHOOL	6,560	5,128
P-913	Camp Zama	730 49	DEP. HIGH SCHOOL	36,570	27,400
S-108	SDHA	740 48	OPEN DINING FAC.	7,152	5,694

SOURCE: SPACE UTILIZATION REPORT BY FACILITY NO. PCN AKA-011 AJO 11/20/87
* Heat Recovery System only

2.2 EMCS PORTION.

This study also included an EMCS feasibility study of thirty-three buildings at Camp Zama and SDHA with a total floor area of 887,741 square feet. These buildings are listed in Table ES-2 which also provides their location, category code, current use, total floor area and usable area. In addition, the EMCS feasibility study includes 151,830 LF of Steam and Domestic Hot Water Systems and 118,262 LF of Perimeter and Street Lighting Systems at Camp Zama and 39,462 LF of Perimeter and Street Lighting at SDHA.

TABLE ES-2
BUILDING DATA

BLDG. NO.	LOCATION	CAT. CODE	CURRENT USE	TOTAL FLOOR AREA (SF)	TOTAL USABLE AREA (SF)
P-101	Camp Zama	610 11	POST HQ BLDG.	253,904	158,938
P-102	Camp Zama	610 11	POST HQ BLDG.	142,113	91,946
P-104	Camp Zama	141 31	500 MI GRP	24,536	15,861
S-134	Camp Zama	821 15	BOILER PLANT	8,623	8,268
P-201	Camp Zama	740 34	GYMNASIUM	33,646	30,244
S-322	Camp Zama	171 15	ARMY BAND TRNG	23,871	18,283
P-332	Camp Zama	721 11	ENL BARRACKS	34,566	33,368
P-333	Camp Zama	722 10	ENL MESS	5,234	4,959
P-341	Camp Zama	721 11	ENL BARRACKS	34,476	27,951
S-350	Camp Zama	821 15	BOILER PLANT	11,834	11,410
S-379	Camp Zama	740 56	EXCH SVC OUTLET	5,589	4,943
P-402	Camp Zama	740 33	COMMUNITY CENTER	6,128	6,000
P-450	Camp Zama	730 72	POST OFFICE	6,032	6,032
S-453	Camp Zama	740 46	CONSOLIDATED CLUB	31,710	23,495
S-500	Camp Zama	730 17	POST CHAPEL	17,400	11,955
S-505	Camp Zama	740 76	THEATER	13,695	10,405
S-533	Camp Zama	740 69	RECREATION BLDG	22,677	15,481
P-704	Camp Zama	550 10	HEALTH CLINIC	29,180	27,642
P-761	Camp Zama	724 10	BACHELOR OFF QTRS	24,536	17,307
P-762	Camp Zama	724 10	BACHELOR OFF QTRS	12,927	8,688

TABLE ES-2 (Continued)
BUILDING DATA

BLDG. NO.	LOCATION	CAT. CODE	CURRENT USE	TOTAL FLOOR AREA (SF)	TOTAL USABLE AREA (SF)
P-763	Camp Zama	724 10	BACHELOR OFF QTRS	12,927	8,688
P-913	Camp Zama	730 49	HIGH SCHOOL	36,570	27,400
P-1042	Camp Zama	530 40	VET FACILITY	3,175	3,075
P-1022	Camp Zama	141 12	AIRFIELD OP BLDG	7,433	5,200
P-807	Camp Zama	740 30	GOLF CLUBHOUSE	5,246	3,920
P-107	SDHA	740 14	CHILD SUPPORT CTR	9,887	9,095
S-108	SDHA	740 48	CONSOLIDATED CLUB	7,152	5,694
S-113	SDHA	740 14	DELI/DRY CLNG & LAUNDY PICKUP	4,030	3,079
P-104	SDHA	740 21	COMMISSARY	21,809	21,590
S-117	SDHA	740 76	THEATER	8,726	5,546
S-134	SDHA	821 15	BOILER PLANT	15,442	14,750
P-337	SDHA	740 66	YOUTH CENTER	2,840	2,156
P-539-1	SDHA	730 48	DEP GRADE SCHOOL	9,827	8,063

SOURCE: SPACE UTILIZATION REPORT BY FACILITY NO. PCN AKA-011 AJO 11/20/87

3.0 PRESENT ENERGY CONSUMPTION.

During fiscal year 1988, Camp Zama and the Sagamihara Dependent Housing Area (SDHA) consumed a total of 500,839.5 MBtu's of energy. Camp Zama used approximately 71 percent and the Sagamihara Dependent Housing Area used the remainder. Tables ES-3 and ES-4 provide energy consumption data for Camp Zama and the Sagamihara Dependent Housing Area, respectively. The cost in dollars is based on the FY88 Budget Exchange Rate of ¥163.10 = $1.00.

Table ES-3
Energy Consumption,
Camp Zama

TYPE ENERGY	AMOUNT	DOLLARS	MBTU
Electricity	28,236,960 KWH	$3,651,009.69	96,372.7
Diesel Fuel	1,837,078 GALS	$1,194,100.70	254,802.7
LPG (Propane)	11,321 Cubic Meters	$ 17,352.85	1,136.6
Kerosene	19,928 GALS	$ 12,953.20	2,690.3
TOTAL		$4,875,416.44	355,002.3

Table ES-4
Energy Consumption,
Sagamihara Dependent Housing Area (SDHA)

TYPE ENERGY	AMOUNT	DOLLARS	MBTU
Electricity	9,166,248 KWH	$1,178,181.59	31,284.4
Diesel Fuel	824,499 GALS	$ 535,924.35	114,358.0
LPG (Propane)	1,940 Cubic Meters	$ 2,973.64	194.8
TOTAL		$1,717,079.58	145,837.2

3.1 ENERGY CONSUMPTION OF STUDY BUILDINGS VS BASEWIDE CONSUMPTION.

3.1.1 STUDY BUILDINGS.

Table ES-5 provides a tabulated list by building of the calculated annual utilities usage of the buildings in the Energy Savings Opportunity Survey (ESOS) portion of this study. Annual energy consumption figures for the three facilities were estimated using the Carrier Air Conditioning Company E20 computerized building energy simulation program.

Table ES-5
Facility Consumption Baseline
Camp Zama/SDHA

BLDG NO.	USE	BASELINE MBTU
P-912, Camp Zama	Dependent High School	279.80
P-913, Camp Zama	Dependent High School	1,644.00
S-108, SDHA	Consolidated Open Dining Facility	523.99

3.1.2 TOTAL CONSUMPTION VS STUDY BUILDINGS

At Camp Zama the energy consumption of the study buildings represents approximately one-half of one percent of Camp Zama's total consumption while Building No. S-108 at the SDHA represent approximately three tenths of one percent of SDHA's consumption.

4.0 HISTORICAL ENERGY CONSUMPTION.

4.1 CAMP ZAMA.

Energy consumption data for FY85 (New Baseline) through FY88 are shown in Chart ES-1 for Camp Zama. Total consumption in FY85 was 329,287.3 MBtu, in FY86 it was 358,306.3 MBtu (8.8% over the FY85 baseline), in FY87 it was 362,643.1 MBtu (10.1% over the the FY85 baseline), and in FY88 it was 355,002.3 MBtu (7.8% over the the FY85 baseline).

4.2 SAGAMIHARA DEPENDENT HOUSING AREA (SDHA).

Energy consumption data for FY85 (New Baseline) through FY87 are shown in Chart ES-2 for the SDHA. Total consumption in FY85 was 139,112.6 MBtu, in FY86 it was 151,697.7 MBtu (9.0% over the FY85 baseline), and in FY87 it was 145,943.5 MBtu (4.9% over the FY85 baseline), and in FY88 it was 145,837.2 MBtu (4.8% over the FY85 baseline).

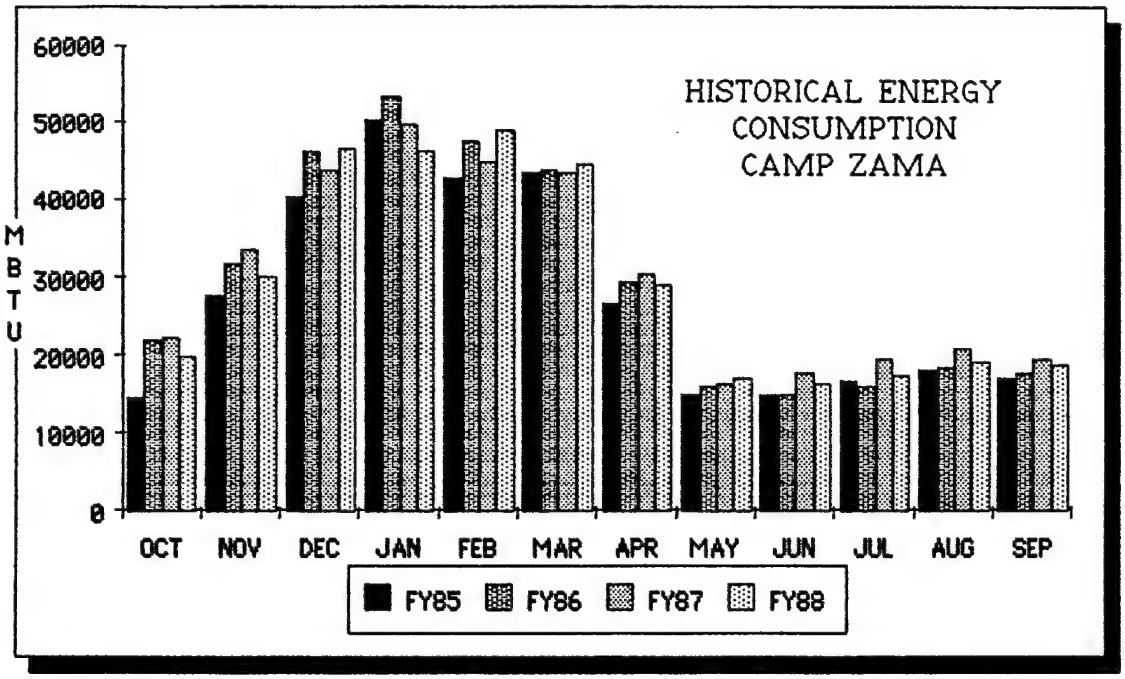


CHART ES-1

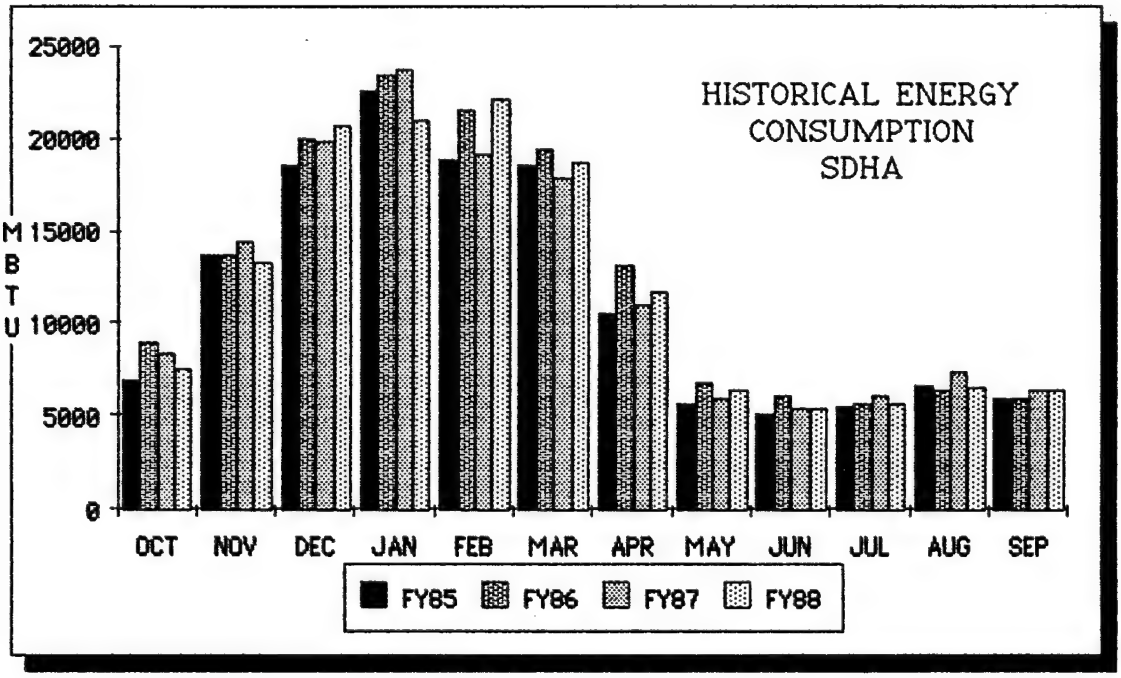


CHART ES-2

5.0 REEVALUATED PROJECTS RESULTS.

In 1982 under Contract No. DACA84-80-C-0152, an Energy Engineering Analysis Program (EEAP) for U.S. Army Garrison, Honshu, Japan study was accomplished. Those projects which were identified in the 1982 study but have not yet been accomplished have been reevaluated and the results are summarized in the following paragraphs.

5.1 FY85 - CEILING INSULATION, BUILDING NO. 200, YOKOHAMA NORTH DOCK.

The FY82 EEAP Study recommended the installation of rigid ceiling insulation (R19 value) with an annual savings of 425 MBtu valued at $7,100 in this building. The facility's roof U-value was analyzed during this study and was found to be 0.05. Since this was very close to DoD guidance of 0.03, only $470.81 worth of energy (35.79 MBtu/year) could be saved each year. The cost to install 20,748 square feet of R19 rigid ceiling insulation was $11,826.36 which provided a simple payback of 25.12 years and an SIR of 0.54. Based on the above information, this ECO is not economically feasible at this point in time.

5.2 FY84 - CEILING INSULATION (FAMILY HOUSING), SAGAMI GENERAL DEPOT.

The FY82 EEAP Study recommended the removal and replacement of gypsum board ceilings and the installation of ceiling insulation (R19 value), a vapor barrier, and attic ventilation in Building Nos. P-706 through P-7014, Sagami General Depot with an annual savings of 1,070 MBtu valued at $15,700. The roof U-value of these facility's was analyzed during this study as shown in Appendix C, and was found to be 0.11. Roof ventilation was available and therefore, no additional ventilation was deemed necessary nor was a vapor barrier required. Energy savings per building was (14.22 MBtu per year) with a cost savings of $231.15 per year based on the graphs used in Appendix B1. The cost to install R22 blown-in cellulose ceiling insulation was $2,702.12 per building which provided a simple payback of 11.67 years and an SIR of 1.06. Based on the above information, this ECO is considered economically feasible for each building and should be accomplished.

5.3 FY84 - CEILING INSULATION, VARIOUS BUILDINGS, CAMP ZAMA.

The FY82 EEAP Study recommended the installation of ceiling insulation (R19 value), a vapor barrier, and attic ventilation in 31 buildings at Camp Zama with an annual savings of 2,970 MBtu valued at $43,600. Insulation has been installed in many buildings and some buildings have been demolished. Eleven buildings remained to be insulated when this study was initiated. Since then, building S-743 has also been demolished. The following ten buildings still require insulation: S-106, S-112, S-113, S-120, S-160, S-262, S-300, S-722, S-731, and S-996. Attic ventilation was available and therefore, no additional ventilation was deemed necessary nor was a vapor barrier required. Energy savings

(MBtu/Dollars), the investment cost, the simple payback and the SIR are presented in Table ES-6 for each building.

TABLE ES-6
Energy Savings, Investment Cost,
Simple Pay Back, and SIR

Bldg. No.	Savings MBtu	Savings ($)	Investment Cost	Simple Payback	SIR
S-106	15.18	251.65	1,946.70	7.73	1.61
S-112	56.84	978.42	6,486.94	6.63	1.85
S-113	19.50	335.81	2,099.50	6.25	1.97
S-120	158.53	2,626.80	16,000.74	6.09	2.04
S-160	31.20	517.07	4,004.64	7.74	1.61
S-262	28.59	473.87	3,668.86	7.74	1.61
S-300	108.49	1,797.79	13,924.57	7.74	1.61
S-722	28.18	467.04	3,615.30	7.74	1.61
S-731	30.28	521.28	3,455.65	6.62	1.85
S-996	20.15	359.31	1,620.00	4.51	2.70

Based on the above information, this ECO for each building is economically feasible and should be accomplished.

5.4 FY85 - REMOTE ZONE TEMPERATURE CONTROL SYSTEM (ECIP), CAMP ZAMA.

5.4.1 GENERAL DESCRIPTION.

This project proposed the installation of a remote heating hot water zone temperature control system using a centralized radio control system including a microcomputer with CRT terminal, radio transmitters, and radio switches. Radio switches were to be installed at 32 stations to control valves and electric motors.

5.4.2 PROPOSED EMCS RELATED ECO ANALYSIS.

This project previously contemplated saving 10,026 MBtu/year of heating energy. 8,726 MBtu would come from temperature setback and 1,300 MBtu/year would come from heating hot water and steam line control with shut-off valves. In addition, 415 MBtu/year of electricity savings would come from the control of heating hot water circulating pumps in Boiler Plant S-505, Heat Exchanger Building S-430 (since demolished), and Heat Exchanger Building Nos. S-264, S-337, and S-950. In view of the fact that Building S-430 has been demolished and because of the inclusion in the original project of savings for night set-back in BEQ/BOQ facilities which will not be implemented, the overall savings will be somewhat reduced. This ECO is included in the EMCS feasibility portion of this study.

5.5 FY85 - REMOTE ELECTRICAL EQUIPMENT CONTROL, CAMP ZAMA

5.5.1 GENERAL DESCRIPTION.

This project proposed the installation of radio receiver switches at selected electrical equipment for load shedding and start/stop operation from a central radio control center (to be installed under ECIP Project—Remote Zone Temperature Control System, Camp Zama). These switches will control air conditioning systems at Building Nos. P-101, P-102 S-112, S-120, P-235, S-252, P-253, S-270, S-310, T-315, S-316, S-322, P-332, P-333, P-341, S-344, S-346, S-379, S-406, S-453, S-500, S-505, S-533, S-625, S-643, S-661, S-666, S-671, S-680, P-704, P-761, P-762, P-763, S-840, P-914, P-1020, P-1026, and P-1042.

5.5.2 PROPOSED EMCS RELATED ECO ANALYSIS.

This project previously contemplated saving 500 MBtu/year of electricity by remotely controlling the on/off periods of the installed air conditioning systems. In addition, it contemplated saving 170 KW/year in demand charges. Seventeen of the thirty-eight facilities (P-101, P-102, S-322, P-332, P-333, P-341, S-379, S-453, S-500, S-505, S-533, P-704, P-761, P-762, P-763, P-914 and P-1042) are included in the EMCS feasibility portion of this study. Building S-112 does not have a central air conditioning unit installed. Two of the facilities (S-252 and P-1020) have been demolished and the following facilities are scheduled for demolition during the dates indicated: S-310 (Mar-Apr 91), S-661 (Jun-Jul 90), S-666 (Feb-Mar 91), and S-680 (FY89). The remaining fourteen facilities (S-120, P-235, S-270, T-315, S-316, S-344, S-346, S-406, S-625, S-643, S-671, S-840, and S-1026) are included in the EMCS feasibility portion of this study.

5.6 FY82 - HEATING HOT WATER TEMPERATURE CONTROL, BOILER PLANT, BUILDING S-134, CAMP ZAMA.

5.6.1 GENERAL DESCRIPTION.

This project proposed the installation of a heating hot water (HHW) temperature control system on the HHW heat exchanger located in Boiler Plant, Building No. S-134, Camp Zama which serves Building Nos. 101 and 102. With automatic control of the HHW supply temperature, a night setback could be achieved and regular temperature could be restored in the morning.

5.6.2 PROPOSED EMCS RELATED ECO ANALYSIS.

This project is currently included in the EMCS feasibility portion of this study. Calculations indicate an overall savings of 10,256.4 MBtu/year at an annual savings of $68,619.33. The costs for modifications and controls would be $5,702.00.00. Simple Payback: 0.08 years. SIR: 218.57.

5.7 FY82 - HEATING HOT WATER TEMPERATURE CONTROLS, HEAT EXCHANGERS, BUILDING NOS. S-264, S-337, S-430, AND S-950, CAMP ZAMA.

5.7.1 GENERAL DESCRIPTION.

This project proposed the installation of a heating hot water (HHW) temperature control system on the HHW heat exchangers located in Heat Exchanger Building Nos. S-264, S-337, and S-950, Camp Zama. (Note: Building No. S-430 has been demolished). This would include electric indicating controllers located at floor level to promote closer control of HHW supply temperatures. With automatic control of the HHW supply temperature, a night setback could be achieved and regular temperature could be restored in the morning.

5.7.2 PROPOSED EMCS RELATED ECO ANALYSIS.

Connecting the pumps and Heat Exchangers in Building Nos. S-264, S-337, and S-950 to the EMCS described in this study, will result in an overall savings of 1,318 MBtu (400 MBtu of Steam and 55 MBtu of Electricity in each of Building Nos. S-264 and S-337, and 368 MBtu of Steam and 40 MBtu Electricity in Building No. S-950). The EMCS costs to implement are $3,657.00 for each of Building Nos. S-264 and S-337, and $4,457.00 for Building No. S-950. Total overall savings amounts to $13,527.42 per year. Simple Payback and Sir for each Facility is : Building No. S-264: $3,657/ $4,770.95 = 0.77 years. SIR: 19.16. Building No. S-337: $3,657.00/$4,770.95 = 0.77 years. SIR: 19.16. Building No. S-950: $4,457.00/$3,985.52 = 1.12 years. SIR: 13.53.

6.0 ENERGY CONSERVATION ANALYSIS.

6.1.1 ECOs INVESTIGATED. The ECOs listed in Table ES-7 were investigated for the appropriate type of facilities indicated.

6.1.2 ECOs RECOMMENDED. The following ECOs were recommended:

a. Reevaluated Projects From FY82 EEAP Study:

(1) Additional Ceiling Insulation Building Nos. P-706 through P-7014, Sagami General Depot.

(2) Additional Ceiling Insulation Building Nos. S-106, S-112, S-113, S-120, S-160, S-262, S-300, S-722, S-731, and S-996, Camp Zama.

b. Install Energy Efficient Lighting/Replace Incandescent Lighting in Building No. S-108 (Consolidated Open Dining Facility), SDHA and Building No. P-912 (Dependent High School) and Building No. P-913 (Dependent High School), Camp Zama. Also, Use More Efficient Lighting Source and Reduce Lighting Levels in Building Nos. P-912 (Dependent High School) and Building No. P-913 (Dependent High School), Camp Zama.

c. Install Make Up Air for Kitchen in Building No. S-108, SDHA (Consolidated Open Dining Facility).

d. Change to High Efficiency Motors in Building No. P-913 (Dependent High School).

e. Install Time Clock on DHW Heater Building No. P-913, SDHA (Dependent High School).

f. Insulate Electric Hot Water Heater Building Nos. S-108, SDHA (Consolidated Open Dining Facility), Building No. P-912 (Dependent High School), and Building No. P-913 (Dependent High School).

g. Add Economizer Cycle (Dry Bulb), Building No. S-108, SDHA (Consolidated Open Dining Facility), Building No. P-912, SDHA (Dependent High School), and Building No. P-913, SDHA (Dependent High School).

h. Install Self-Closing Faucets, Building No. P-912 (Dependent High School) and Building No. P-913 (Dependent High School).

i. Modify Building No. P-1024-1 (Refuse Incinerator) incinerator operating hours.

j. Modify Building No. P-1024-1 (Refuse Incinerator) incinerator furnace controls.

k. Modify and revise Building No. P-1024-1 (Refuse Incinerator) plate heat exchanger controls.

l. Stop Building No. P-1024-1 (Refuse Incinerator) domestic hot water circulation pumps during high use periods.

m. Increase the surface area of the Building No. P-1024-1 (Refuse Incinerator) plate heat exchanger and connect DHWST-2 to the heat recovery system.

n. Use Building No. P-1024-1 (Refuse Incinerator) heat recovery for heating hot water in Boiler Plant P-1024.

TABLE ES-7

ENERGY CONSERVATION OPPORTUNITIES

1. GENERAL
   a. Insulation:
      - Panels
      - Ceiling
      - Walls
      - Roof
      - Piping
      - Ducts
   b. Solar applications
      - Film
      - Heaters
   c. Exterior Building Envelope
      - Storm windows
      - Double glazed windows
      - Weather stripping and caulking
      - Vestibules
      - Reduction of glass area
      - Use air curtains at personnel entrances
      - Load dock seals
   d. Lighting
      - Reduce lighting levels
      - Use more efficient lighting source
      - Replace incandescent lighting
      - Replace light fixtures
      - Use energy conserving flourescent lamps
      - Automated light controls (FM radio controls)
   e. Hot Water
      - Decentralize hot water heaters
      - Install flow restrictors or limited flow showerheads
      - Automatic shutoff water fauscets
      - Use hot water heat pumps
      - Install booster heaters at major water users
      - Lower domestic hot water

TABLE ES-7 (Continued)
ENERGY CONSERVATION OPPORTUNITIES

- Install time clock on heaters
- Shutdown energy to hot water heaters or modify controls
- Control hot water circulation pump
- Capture heat from hot refrigerant gase for heating water
- Insulate hot water heaters.

f. HVAC Systems
- Make HVAC more efficient
  - Upgrade, revise or repair HVAC controls
  - Balance HVAC
  - Install night setback/setup thermostats
- Air handling system
  - Shut off air handling units whenever possible
  - Reduce outside air intake when air must be heated or cooled before use
  - Reduce volume of air circulated through air handling units
  - Install variable air volume (VAV) controls
  - Clean coils
  - Maintain filters
  - Repair and/or maintain air handling controls
  - Prevent air stratification
  - Reduce humidification to minimum requirements
  - Cycle fans
  - Reset thermostats higher during cooling
  - Economizer cycles (dry bulb)
  - Use damper controls to shut off air to unoccupied area
  - Return condensate
  - Heat reclaim from condenser units for preheating of hot water
  - Use heat pumps for hot water heating and facility cooling
  - Change to Variable Air Volume (VAV) system

g. Motor/Equipment
- High efficiency motor replacement
- Improve power factor
- Install minimum sized motor to meet load

TABLE ES-7 (Continued)
ENERGY CONSERVATION OPPORTUNITIES

h. Electrical power
- Improve power factor
- Shed loads during peak electrical use periods
- Investigate transformer loading and reduce transformer over-voltage

2. Boiler Facilities
a. Controls to assure proper combustion air-fuel ratio (Boiler oxygen trim control)
b. Feedwater treatment
c. Waste heat recovery, i.e. exhaust gases, process steam pressure drop, and steam condensate and blowdown
d. Installation of new burner equipment
e. Economizers/air preheaters
f. Reduce excess air
g. Loading characteristics and scheduling versus equipment capacity (equipment optimization)
h. Variable speed circulation pumps or alternate pumps
i. Steam pressure or hot water temperature reductions based on existing and projected requirements
j. Reduction in make-up water quantities
k. Steam driven auxillaries versus electric drives
l. Variable speed induced draft fans and forced draft blowers
m. Instruments and controls to facilitate efficient operations
n. Increase boiler efficiency
o. Repair, replace, or install condensate return system
p. Insulate boiler and boiler piping
q. Check boiler tubes
r. Blowdown controls
s. Reduce pumping flow to include shutting off uneeded circulating pumps if applicable
t. Repair and maintain steam lines and steam traps, if applicable
u. Replace hand valves with automatic controls
v. Provide steam traps (size, operation, type)

TABLE ES-7 (Continued)
ENERGY CONSERVATION OPPORTUNITIES

w. Revise boiler controls

3. Dining Facilities (General ECOs also apply)
   a. Optimize dining facilities operation
   b. Heat reclaim from kitchen exhaust
   c. Heat recovery from dishwasher hot water
   d. Install make up air supply for kitchen area
   e. Shut off range hood exhaust whenever possible
   f. Use of heat pump to heat water and cool dining area

6.1.3 ECOs REJECTED. The following ECOs were rejected for reasons indicated.

1. Insulation:

   - Panels: No applications found other than the roof which would not be economically feasible (see ceiling below).

   - Ceiling: Not economically feasible—six inches of fiberglass insulation is installed in Building No. S-108, SDHA and the "U" value is 0.04. Two inches of rigid insulation is installed in Building Nos. P-912 and P-913 and the "U" value is 0.05. Both exceed DoD criteria which requires a "U" value of only 0.03.

   - Walls: Not applicable—two inches of insulation is installed in Building No. S-108, SDHA ("U" value of 0.08) and Building Nos. P-912 and P-913 ("U" value of 0.10) which exceeds or meets DoD criteria for a "U" value of only 0.10.

   - Roof: Not applicable—see ceiling above.

   - Piping: Not applicable—piping currently insulated.

   - Ducts: Not applicable—duct currently insulated.

2. Solar applications (film and heaters): Not applicable—neither would be beneficial due to the late evening operating hours (Building No. S-108, SDHA only opens after 1700 hours). Solar heating would not be economically feasible for Building Nos. P-912 and P-913 because of the low savings (approximately $471 and $2,070 per year, respectively) versus the large investment. In addition, the energy saving analysis for solar film indicated that while the simple payback was approximately 13.2 years, the SIR for each building analyzed was 0.78.

3. Exterior Building Envelope

   - Storm windows: The analysis for installing storm windows indicated a savings of 6.90, 2.56, & 72.88 MBtu of cooling and heating could be achieved in Building Nos. S-108, P-912, & P-913, respectively. The cost for installation of storm windows was $4,716.06 for S-108, $2,498.03 for P-912 and $86,913.40 for P-913, Camp Zama. The SIR for Bldg. S-108, SDHA was 0.23 and for P-912 it was 0.16 and for P-913 it was 0.0.13. Therefore, this ECO is not economically feasible.

   - Double glazed windows: The analysis for double glazing showed that on average, a savings of 0.093 MBtu/sq. ft. of cooling and heating could be achieved with a total savings of $1.69/sq. ft. per year. The removal of the existing window and replacement with a double-glazed glass window with a thermal break cost $25.27/sq.

ft. Although the simple payback was 14.95 years, the SIR was only 0.81.

- Weather stripping and caulking: Not applicable—Building No. S-108, SDHA recently underwent renovations which removed a number of windows. Weatherstripping/caulking was adequately provided to remaining windows/doors. Building Nos. P-912 and P-913 were recently constructed and weatherstripping/caulking is adequately provided.

- Vestibules: Building Nos. P-912 and P-913 at Camp Zama have vestibules installed. The energy savings for this ECO in Building No. S-108, SDHA result in $28.90 in savings annually. The simple payback for this ECO was 68.36 years and the SIR was 0.19.

- Reduction of glass area. Not applicable—Building No. S-108, SDHA and P-912, Camp Zama both had glass to wall ratios of less than 6% which is well below the DoD recommended 15%. Building No. P-913 was analyzed because its glass to wall ratio was 36% but it exhibited a simple payback of 37.18 years and an SIR of 0.53.

- Use air curtains at personnel entrances: Not applicable to the type of facilities being studied. In addition, Building Nos. P-912 and P-913 both have vestibules.

- Load dock seals: No loading dock in the facilities studied.

4. Lighting

- Reduce lighting levels in Building S-108, SDHA: Not applicable—lighting levels are currently at or below minimum DoD authorized levels.

- Use more efficient lighting source: Not applicable—majority of lighting source in Building No. S-108, SDHA is from fluorescent fixtures. HID sources are not recommended for dining or food service and preparation areas. Dimmable incandescent lighting in the dining area and lounge provides subdued and aesthetic lighting. For Building P-913, it is not economically feasible because the SIR is 0.38.

- Replace standard fluorescent ballast with energy efficient ballast. Not economically feasible (SIR:0.74).

- Replace light fixtures: Not applicable—existing are fluorescent and some incandescents can be converted without replacement.

- Automated light controls (FM radio controls): Not applicable—all lighting turned off by management when facilities are shut down each day.

5. Hot Water

- Decentralize hot water heaters: Not applicable—there is only one hot water heater to supply 170°F water to the pots/pans sink and to pre-heat the dishwasher booster heater water in Building No. S-108, SDHA. In Building Nos. P-912 and P-913, decentralization is not feasible because the heaters serve specific areas widely dispersed throughout the buildings.

- Install flow restrictors or limited flow showerheads: Not applicable—no showers installed.

- Automatic shutoff water faucets: Not economically feasible for Building No. S-108, SDHA because the SIR is 0.78.

- Use hot water heat pumps: Not economically feasible—COP of heat pump must be greater than 5.69 to be economically feasible. Best heat pump has COP of 3.6.

- Install booster heaters at major water users: Not applicable—booster heater currently in use for dishwashers in Building Nos. S-108, SDHA and P-913, Camp Zama. No application can be found for Building P-912.

- Lower hot water temperature: DHW incoming temperature is currently 100°F to 105°F for general use in Building No. S-108. Temperature is required to be 170~180°F for washing pots and pans and a water heater boosts the temperature from 100°F to 170°F for the pot and pan sink.

- Install time clock on heaters: Not economically feasible for Building No. P-912 because the SIR is -0.24.

- Shutdown energy to hot water heaters or modify controls: Not applicable—time clock to be installed which will shut hot water heaters down during unoccupied periods in Building No. P-913. For Building Nos. P-912 and S-108, SDHA, the only method remaining is to manually turn them off each day.

- Control hot water circulation pump: Not applicable—no pumps installed in Building Nos. S-108, SDHA and P-912, Camp Zama.

- Capture heat from hot refrigerant gas for heating water: Not applicable—a/c units operate very little and DHW use is minimal.

6. HVAC Systems

a. Make HVAC more efficient:

- Upgrade, revise or repair HVAC controls: Not applicable—controls are adequate.

- Balance HVAC: Not applicable—Building No. S-108 system recently balanced. Building Nos. P-912 and P-913 have fan coil units which each serve only one area.

- Install night setback/setup thermostats: Not applicable—systems turned off during unoccupied periods.

b. Air handling system:

- Shut off air handling units whenever possible: Units now turned off whenever possible.

- Reduce outside air intake when air must be heated or cooled before use: Not applicable—outside air intake limited.

- Reduce volume of air circulated through air handling units: Not applicable—air flow is presently at minimum level to meet load.

- Install variable air volume (VAV) controls: Not possible without a complete remodeling of the system to install a VAV system, which is not economically feasible.

- Clean coils: Not applicable—coils are cleaned on a recurring basis during the normal PM cycle.

- Maintain filters: Not applicable—filters are cleaned or replaced when dirty.

- Repair and/or maintain air handling controls: Not applicable—controls are repaired when required and maintained on a recurring basis during the normal PM cycle.

- Prevent air stratification: Not applicable—cooling and heating is via concealed ceiling ductwork which moves air to prevent stratification. In addition, ceilings are not over 8'0" high.

- Reduce humidification to minimum requirements: Not applicable—currently maintained at minimum.

- Cycle fans: Not applicable.

- Reset thermostats higher during cooling: Not applicable—currently maintained at DoD level of 78°F.

- Use damper controls to shut off air to unoccupied area: Not applicable.

- Return condensate: Not applicable.

- Heat reclaim from condenser units for preheating of hot water: Not applicable—a/c units operate very little and DHW use is minimal.

- Use heat pumps for hot water heating and facility cooling. Not economically feasible—COP of heat pump must be greater than 5.69 to be economically feasible. Best heat pump has COP of 3.6.

- Change to Variable Air Volume (VAV) system: Not possible without a complete remodeling of the system which is not economically feasible.

7. Motor/Equipment

- High efficiency motor replacement: There were no motors which qualified in Building Nos. S-108, SDHA and P-912, Camp Zama. In addition, four of the six motors in Building No. P-913 did not qualify because their SIRs were 0.22 (3 HP), 0.22 (3 HP), 0.95 (10 HP), and 0.95 (10 HP) for condensate and chilled water circulating pumps.

- Improve power factor: Not applicable—power factor problems usually result from buildings using older motors. Since the motors in these buildings are relatively new, power factor improvements are not needed and cannot be economically achieved.

- Install minimum sized motor to meet load: Not applicable—motors currently installed are minimum size required for load.

8. Electrical power

- Improve power factor: Not applicable—power factor problems usually result from buildings using older motors. Since the motors in these buildings are relatively new, power factor improvements are not needed and cannot be economically achieved.

- Shed loads during peak electrical use periods: Not applicable—to be accomplished by the Energy Monitoring and Control System contemplated by this study.

- Investigate transformer loading and reduce transformer over-voltage: Not applicable—transformer overloading usually occurs when a building's use changes such that equipment is added to a building beyond the transformer capacity. This has not occurred in these buildings. In addition, the transformer is connected as a wye system and balancing of all phases is adequate. Therefore, transformer overloading and overvoltage are not a problem.

9. Boiler Facilities:

- Shut down the boilers in the Boiler Plant (Building No. P-1024) during low use hours: Not feasible because the off period (0100~0400) is so short that the recovery losses after restarting would offset any savings. In addition, the frequent shutdown of boilers will shorten their refractory life due to thermal changes.

10. Dining Facilities (General ECOs also apply)

- Optimize dining facilities operation: Not applicable—Building No. S-108, SDHA currently operates at optimum. Building No. P-913, Camp Zama has minimal use.

- Heat reclaim from kitchen exhaust: Not economically feasible.

- Heat recovery from dishwasher hot water: Not economically feasible in Building No. S-108, SDHA because the SIR is 0.18. Building No. P-913's kitchen receives only minimal use during lunch hour.

- Install make up air supply for kitchen area: Not applicable to Building No. P-912 and Building No. P-913 which receive only minimal use during the lunch hour.

- Shut off range hood exhaust whenever possible: Not applicable to Building No. P-912 and range hoods currently shut off when not in use in Building No. P-913. In Building No. S-108, automating shut off is not economically feasible because the SIR is 0.45.

- Use of heat pump to heat water and cool dining area. Not economically feasible—COP of heat pump must be greater than 5.69 to be economically feasible. Best heat pump has COP of 3.6.

6.1.4 ECIP PROJECTS DEVELOPED FOR ECOs. None.

6.1.5 OTHER ENERGY CONSERVATION PROJECTS DEVELOPED FOR ECOs.

Table ES-10 (Prioritized List of Energy Conservation Opportunities) lists in decending order of Savings to Investment Ratio (SIR) all ECOs developed as of the analysis date of 1/89. For each ECO the programmed year cost (escalated construction cost, contingency and SIOH), annual energy savings by type and amount, annual dollar savings, the simple amortization (payback) period, and the year in which it is tentatively programmed is provided.

6.1.6 OPERATIONAL OR POLICY CHANGE RECOMMENDATIONS.

Camp Zama should commence stocking the energy saving lite-white 34-watt fluorescent lamps (FSN 9G6240-01-053-8462). When conventional 40-watt fluorescent lamps burn out they should be replaced with these lower wattage lamps. In addition, when ballasts burn out they should be replaced with high-efficiency electromagnetic ballasts.

7.0 ENERGY MONITORING AND CONTROL SYSTEM (EMCS) FEASIBILITY STUDY AND ANALYSIS.

7.1 GENERAL.

An EMCS is an energy management system which uses minicomputers, microcomputers, associated peripherals, instrumentation, control equipment, and applications programs written in high level computer languages. The EMCS is configured into a network with control functions at multiple locations and a central point of operator control and supervision. An EMCS system may be used to effect energy and manpower savings for heating, ventilating and air conditioning, process equipment, lighting, chillers, and boilers. The EMCS may also be used to assist in building and maintenance management.

7.2 SURVEY AND ANALYSIS.

Each of the buildings and systems designated in the scope of work was surveyed to determine the details of the existing energy consuming equipment. Each piece of equipment installed was then matched with its appropriate schematic diagram and Input/Output (I/O) summary table. Based on the I/O table, the energy savings were calculated. After the energy savings were determined, the necessary equipment modifications (sensors, actuators, and control devices) were identified and estimates of their costs were made.

After the costs for this portion of the study were determined, a life cycle cost analysis was performed on all buildings to determine their savings to investment ratio (SIR) as shown in Table ES-11. Those whose SIR was less than 0.75 were eliminated from further study. Those

TABLE ES-8
PRIORITIZED ENERGY CONSERVATION OPPORTUNITIES

Analysis Date: 1/89

Bldg. No.	Use	Energy Conservation Opportunity (ECO)	Annual Energy Savings Electricity MBtu	Steam MBtu	Value ($)	Construction and SIOH Cost ($)	SIR	Simple Payback (Yrs)	Funding Cat.	Year
P-1024-1	Incinerator	Modify Incinerator Operating Hours	0.00	38.70	258.90	0.00	Infinity	Infinity	O&M	FY90
P-1024-1	Incinerator	Modify /Revise PHE Controls	0.00	430.15	2,877.70	41.60	1,256.41	0.01	O&M	FY90
S-108	Open Dining Fac.	Insulate Electric Hot Water Heater	13.11	0.00	499.36	20.65	266.19	0.04	O&M	FY90
P-1024-1	Incinerator	Stop DHW Circ. Pump During High Use	46.47	0.00	1,770.04	97.18	200.50	0.05	O&M	FY90
P-912	Dep. High School	More Efficient Lighting Sources	22.22	0.00	1,413.69	341.46	27.59	0.24	O&M	FY90
P-1024-1	Incinerator	Increase Size PHE/Connect DHWST-2	0.00	596.76	3,992.32	2,866.92	25.29	0.71	QRIP	FY91
P-913	Dep. High School	Insulate Electric Hot Water Heater	3.62	0.00	137.89	70.80	21.44	0.51	O&M	FY90
P-912	Dep. High School	Insulate Electric Hot Water Heater	0.98	0.00	37.33	19.47	19.64	0.52	O&M	FY90
P-912	Dep. High School	Energy Efficient Lighting	1.55	0.00	58.17	39.00	16.40	0.67	O&M	FY90
P-913	Dep. High School	Energy Efficient Lighting	65.48	0.00	2,457.36	1,650.00	16.37	0.67	O&M	FY90
S-108	Open Dining Fac.	Energy Efficient Lighting	2.27	0.00	85.19	70.00	12.66	0.82	O&M	FY90
S-108	Open Dining Fac.	Install Makeup Air in Kitchen	59.91	0.00	2,281.97	1,824.51	10.02	0.79	QRIP	FY91
P-913	Dep. High School	Replace Incandescent Lighting	0.57	0.00	19.74	25.76	8.36	1.30	O&M	FY90
P-912	Dep. High School	Replace Incandescent Lighting	3.13	0.00	108.42	141.68	8.34	1.31	O&M	FY90
S-108	Open Dining Fac.	Add an Economizer Cycle	63.92	0.00	2,434.71	2,356.41	8.28	0.96	QRIP	FY91
S-108	Open Dining Fac.	Replace Incandescent Lighting	7.63	0.00	261.38	386.40	7.71	1.49	O&M	FY90
P-913	Dep. High School	Install Time Clock on DHW Heater	14.95	0.00	569.45	775.89	7.52	1.36	O&M	FY90
P-913	Dep. High School	Reduce Lighting Levels	54.93	0.00	2,095.78	3,088.46	7.47	1.47	O&M	FY90
P-1024-1	Incinerator	Revise Incinerator Furnace Controls	0.00	79.90	534.53	1,560.78	6.22	2.91	O&M	FY92
P-912	Dep. High School	Reduce Lighting Levels	6.06	0.00	234.84	458.00	5.65	1.95	O&M	FY90
P-913	Dep. High School	Install Self-Closing Faucets	15.05	0.00	573.25	1,828.96	3.21	3.19	O&M	FY90
P-912	Dep. High School	Install Self-Closing Faucets	7.53	0.00	286.82	914.48	3.21	3.18	O&M	FY90
P-913	Dep. High School	Add an Economizer Cycle	239.89	0.00	9,137.41	25,648.32	2.85	2.80	O&M	FY92
*S-996	Dep. Middle School	Insulate Ceiling	7.15	13.00	359.31	1,620.00	2.70	4.51	O&M	FY90
P-913	Dep. High School	Change to High Efficiency Motors	4.92	0.00	187.64	876.98	2.19	4.67	O&M	FY90
*S-120	OPS Gen Purpose	Insulate Ceiling	49.88	108.65	2,626.80	16,000.74	2.04	6.09	O&M	FY90
*S-113	Gen. Inst 500 MI GRP	Insulate Ceiling	6.54	12.96	335.81	2,099.52	1.97	6.25	O&M	FY90
*S-731	Utilities JED	Insulate Ceiling	10.15	20.13	521.28	3,455.65	1.85	6.62	O&M	FY90
*S-112	OPS 500 MI GRP	Insulate Ceiling	19.05	37.79	978.42	6,486.94	1.85	6.63	O&M	FY90
*S-722	JS High School	Insulate Ceiling	8.87	19.31	467.04	3,615.30	1.61	7.74	O&M	FY90
*S-300	HQ Bldg. JSDF	Insulate Ceiling	34.14	74.35	1,797.79	13,924.57	1.61	7.74	O&M	FY90
*S-262	Admin. Gen. Purpose	Insulate Ceiling	9.00	19.59	473.87	3,668.86	1.61	7.74	O&M	FY90
*S-160	Admin. 500 MI GRP	Insulate Ceiling	9.82	21.38	517.07	4,004.64	1.61	7.74	O&M	FY90
*S-106	Admin. 500 MI GRP	Insulate Ceiling	4.78	10.40	251.65	1,946.70	1.61	7.73	O&M	FY90
P-912	Dep. High School	Add Economizer Cycle	25.81	0.00	983.12	6,336.14	1.24	6.44	O&M	FY90
P-1024-1	Incinerator	Use Heat Recovery for HHW	-27.54	551.70	2,641.87	48,795.60	1.15	18.47	O&M	FY90
*P7006	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7007	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7008	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7009	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7010	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7011	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7012	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7013	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
*P7014	Dependent Housing	Insulate Ceiling	4.79	9.43	231.50	2,702.12	1.06	11.69	O&M	FY90
TOTALS			834.95	2119.64	46,351.42	181,377.45				

* ECOs from FY82 EEAP Study.

TABLE ES-9
BUILDING HARDWARE COSTS, ENERGY SAVINGS, SIMPLE PAYBACK AND SIR
TOTAL

BLDG. *	LOCATION	USE	INPUT/OUTPUT POINT COUNT		COSTS			SAVINGS				VALUE OF SVGS	INVEST-MENT TOTAL	SIMPLE PAY-BACK	SIR
					EMCS HARDWARE INSTRUMENT/CNT'RL		MODS TO EXSTG SYSTEMS								
			DIGITAL	ANALOG	DIGITAL	ANALOG		KWH	GALS/YR	MBH	M/H				
P-101	CP. Zama	HQ. BLDG.	2	1	$400	$443	$1,941	0	46,853	6,499	0	$43,478	$2,784	0.06	207.56
P-102	CP. Zama	HQ. BLDG	2	1	$400	$443	$1,941	0	27,094	3,758	0	$25,141	$2,784	0.11	120.02
P-104	CP. Zama	500 MI Grp.	22	39	$4,594	$18,195	$2,870	25,102	1,951	356	32	$5,406	$25,659	4.75	2.09
S-134	CP. Zama	Steam Plant	24	64	$6,608	$33,128		16,871	30,821	4,332	10	$22,346	$39,736	1.78	7.18
P-201	CP. Zama	Gym	1	8	$202	$3,614	$155	0	0	0	0	$0	$3,971	0.00	0.00
S-322	CP. Zama	Band Trg. Fac.	7	23	$1,508	$12,816		53,263	4,346	785	8	$11,040	$14,324	1.30	7.72
P-332	CP. Zama	Enl. Bks.	87	171	$17,464	$79,798		54,080	1,189	349	164	$9,839	$97,262	9.89	0.89
P-333	CP. Zama	Enl. Mess	12	22	$2,506	$11,449		50,761	1,987	449	12	$8,568	$13,955	1.63	5.68
P-341	CP. Zama	Enl. Bks	84	173	$17,096	$82,295	$15,375	34,634	0	118	304	$7,664	$114,766	14.97	0.56
S-350	CP. Zama	Steam Plant	32	68	$8,775	$35,657		1,075	60,635	8,414	22	$39,812	$44,432	1.12	11.87
S-379	CP. Zama	Exch. Svc. Outlet	7	12	$1,508	$6,278		26,498	1,545	305	8	$4,962	$7,786	1.57	6.14
P-402	CP. Zama	ACS	18	28	$4,024	$15,859	$2,255	11,276	382	92	8	$1,904	$22,138	11.63	0.78
P-450	CP. Zama	Post Office	27	55	$5,469	$26,007	$3,690	18,419	800	174	8	$3,220	$35,166	10.92	0.85
* S-453	CP. Zama	Consol. Club	56	81	$12,064	$40,581		60,878	1,562	424	64	$10,029	$52,645	5.25	0.98
S-500	CP. Zama	Chapel	21	31	$4,524	$19,974		59,431	1,315	385	16	$9,113	$24,498	2.69	3.28
S-505	CP. Zama	Theater	39	43	$9,002	$21,530	$2,665	49,246	4,741	826	64	$11,467	$33,197	2.90	3.51
S-533	CP. Zama	Rec. Ctr.	9	19	$1,901	$8,845	$820	8,199	0	28	20	$1,274	$11,566	9.08	0.91
P-704	CP. Zama	Health Clinic	23	35	$5,038	$17,824		54,356	3,668	694	20	$10,678	$22,862	2.14	4.57
P-761	CP. Zama	BOQ	56	111	$11,326	$52,099	$19,680	24,802	1,139	243	196	$6,320	$83,105	13.15	0.70
P-762	CP. Zama	BOQ	32	63	$6,574	$29,659	$9,840	13,561	578	126	100	$3,339	$46,073	13.80	0.67
P-763	CP. Zama	BOQ	32	63	$6,574	$29,659	$9,840	13,561	578	126	100	$3,339	$46,073	13.80	0.67
P-807	CP. Zama	Golf Club House	7	11	$1,508	$5,469		84,878	0	290	8	$11,117	$6,977	0.63	12.95
P-913	CP. Zama	High School	60	60	$12,356	$27,455		78,586	5,061	970	184	$16,826	$39,811	2.37	4.08
P-1022	CP. Zama	Airfield OPS	12	22	$2,674	$10,795		2,321	14	10	8	$398	$13,469	33.85	0.25
P-1042	CP. Zama	Vet. Fac.	13	40	$2,930	$19,456		18,936	855	183	10	$3,359	$22,386	6.66	1.41
Utility	CP. Zama	Street/Per. Ltg.	54	0	$10,800	$0		105,482	0	360	0	$13,713	$10,800	0.79	10.31
P-104	SDHA	Commissary	36	52	$9,132	$26,408		62,008	175	236	32	$8,556	$35,540	4.15	1.99
P-107	SDHA	Child Spt. Ctr.	11	18	$3,813	$8,977		48,178	1,992	441	8	$8,195	$12,790	1.56	5.96
S-108	SDHA	Consol. Club	7	12	$1,508	$6,278		14,298	1,683	282	8	$3,504	$7,786	2.22	4.70
S-113	SDHA	Deli/Laundry PU	11	23	$2,297	$11,414	$1,230	4,741	531	90	28	$1,400	$14,941	10.67	0.95
S-117	SDHA	Theater	7	12	$1,508	$6,278		25,037	1,765	330	8	$4,976	$7,786	1.56	6.29
S-134	SDHA	Steam Plant	48	84	$12,312	$43,068		84,146	67,675	9,674	26	$55,232	$55,380	1.00	12.21
P-337	SDHA	Youth Ctr.	10	22	$2,099	$10,334	$1,025	11,872	240	74	24	$2,016	$13,458	6.68	1.32
S-539-1	SDHA	Elementary Sch.	10	14	$2,217	$7,016		26,316	1,940	359	8	$5,304	$9,233	1.74	5.68
Utility	SDHA	Street Ltg	24	0	$4,800	$0		39,947	0	136	0	$5,193	$4,800	0.92	8.79
		GRAND TOTALS	903	1,481	$197,511	$729,101	$73,327	1,182,759	273,115	41,918	1,508	$378,728	$999,939		

* To be demolished in 1995.

TABLE ES-9 (CONT'D)
BUILDING HARDWARE COSTS, ENERGY SAVINGS, SIMPLE PAYBACK AND SIR TOTAL

BLDG. #	LOCATION	USE	INPUT/OUTPUT POINT COUNT		COSTS			SAVINGS				VALUE OF SVGS	INVEST-MENT TOTAL	SIMPLE PAY-BACK	SIR
					EMCS HARDWARE INSTRUMENT/CNT'RL		MODS TO EXSTG SYSTEMS	KWH	GALS/YR	MBH	M/H				
			DIGITAL	ANALOG	DIGITAL	ANALOG									
# -	CP. Zama	Remote Zone Temp	22	53	$4,416	$25,199	$165,816	0	44,434	6,163	0	$41,230	$195,431	4.74	3.88
#S-264	CP. Zama	HHW Temp CTRL	4	6	$800	$2,857		16,121	2,885	455	2	$5,092	$3,657	0.72	15.52
#S-337	CP. Zama	HHW Temp CTRL	4	6	$800	$2,857		16,121	2,885	455	2	$5,092	$3,657	0.72	15.52
#S-950	CP. Zama	HHW Temp CTRL	8	6	$1,600	$2,857		11,822	2,655	408	2	$4,282	$4,457	1.04	10.98
#S-120	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		5,973	0	20	6	$824	$7,276	8.83	0.93
#S-120	CP. Zama	Remote Elect. Eq.	23	48	$4,756	$22,317	$7,380	9,227	0	32	40	$1,635	$34,453	21.07	0.39
#S-270	CP. Zama	Remote Elect. Eq.	10	22	$1,996	$10,938		12,025	0	41	12	$1,687	$12,934	7.67	1.07
#T-315	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		24,320	0	83	6	$3,224	$7,276	2.26	3.61
#S-316	CP. Zama	Remote Elect. Eq.	7	15	$1,390	$8,464	$1,025	8,106	0	28	10	$1,171	$10,879	9.29	0.88
#S-344	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		4,040	0	14	6	$596	$7,276	12.22	0.67
#S-346	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		23,123	0	78	8	$3,054	$7,276	2.38	3.42
#S-406	CP. Zama	Remote Elect. Eq.	10	22	$1,996	$11,294		45,971	0	157	16	$6,147	$13,290	2.16	3.77
#S-625	CP. Zama	Remote Elect. Eq.	24	47	$4,760	$21,935	$4,100	10,647	0	36	40	$1,787	$30,795	17.23	0.48
#S-643	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		7,293	0	25	6	$1,015	$7,276	7.17	1.14
#S-671	CP. Zama	Remote Elect. Eq.	10	23	$1,996	$11,747		11,470	0	39	14	$1,631	$13,743	8.43	0.97
PAST PROJECTS GRAND TOTALS			147	308	$29,500	$151,855	$178,321	206,259	52,859	8,034	170	$78,466	$359,676		

PAST ECOs FROM FY82 EEAP STUDY WHICH ARE RELATED TO EMCS.

satisfying the criteria were then grouped from the highest to the lowest SIR as shown in Table ES-10.

The total number of I/O points were then determined for all viable systems in order to determine the EMCS size and other costs. Finally, a Life Cycle Cost Analysis was completed on the overall project.

The investment cost including SIOH, is $3,993,453.24, the energy savings are 4,354.42 MBtu of electricity, and 44,892.33 MBtu of distillate fuel valued at $422,922.63 and the labor savings are valued at $9,193.60. The simple payback is 9.24 years and the SIR is 1.30. This project satisfies all the criteria for an ECIP project.

8.0 PROJECT BREAKOUTS WITH TOTAL COST AND SIR.

8.1 ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP).

• Energy Monitoring and Control System (EMCS), Camp Zama/SDHA. Programmed Year Cost: $3,993,453.24. SIR: 1.30.

8.2 QUICK RETURN ON INVESTMENT PROGRAM (QRIP).

• Heat Recovery System (Increase Size of PHE/Connect DHWST-2), Building No. P-1024-1, Camp Zama. Programmed Year Cost: $2,866.92 Simple Payback: 0.71 Years. SIR: 25.29.

• Add an Economizer Cycle, Building S-108, SDHA. Programmed Year Cost: $2,356.41. Simple Payback: 0.96 Years. SIR: 8.28

• Install Makeup Air in Kitchen, Building S-108, SDHA. Programmed Year Cost: $1,824.51. Simple Payback: 0.79 Years. SIR: 10.02

8.3 OTHER FUNDING PROGRAMS.

The remaining ECOs from Table ES-8 are listed below. They are to be accomplished using local OMA funds.

a. Consolidated Dining Facility, Building No. S-108, SDHA

(1) Replace Lighting (Install Energy Efficient Lamps and Replace Incandescent Lamps). Programmed Year Cost: $346.57. Simple Payback: 0.82 and 1.48 years respectively. SIR: 12.66 and 7.71 respectively.

(2) Insulate Electric Hot Water Heater. Programmed Year Cost: $20.65. Simple Payback: 0.04 years. SIR: 266.19

TABLE ES-10
BUILDING HARDWARE COSTS, ENERGY SAVINGS, SIMPLE PAYBACK AND SIR
TOTAL

BLDG. #	LOCATION	USE	INPUT/OUTPUT POINT COUNT		COSTS			SAVINGS				VALUE OF SVGS	INVEST-MENT TOTAL	SIMPLE PAY-BACK	SIR
					EMCS HARDWARE INSTRUMENT/CNT'RL		MODS TO EXSTG SYSTEMS	KWH	GALS/ YR	MBH	M/H				
			DIGITAL	ANALOG	DIGITAL	ANALOG									
P-101	CP. Zama	HQ. BLDG.	2	1	$400	$443	$1,941	0	46,853	6,499	0	$43,478	$2,784	0.06	207.56
P-102	CP. Zama	HQ. BLDG	2	1	$400	$443	$1,941	0	27,094	3,758	0	$25,141	$2,784	0.11	120.02
#S-264	CP. Zama	HHW Temp CTRL	4	6	$800	$2,857		16,121	2,885	455	2	$5,092	$3,657	0.72	15.52
#S-337	CP. Zama	HHW Temp CTRL	4	6	$800	$2,857		16,121	2,885	455	2	$5,092	$3,657	0.72	15.52
P-807	CP. Zama	Golf Club House	7	11	$1,508	$5,469		84,878	0	290	8	$11,117	$6,977	0.63	12.95
S-134	SDHA	Steam Plant	48	84	$12,312	$43,068		84,146	67,675	9,674	26	$55,232	$55,380	1.00	12.21
S-350	CP. Zama	Steam Plant	32	68	$8,775	$35,657		1,075	60,635	8,414	22	$39,812	$44,432	1.12	11.87
#S-950	CP. Zama	HHW Temp CTRL	8	6	$1,600	$2,857		11,822	2,655	408	2	$4,282	$4,457	1.04	10.98
Utility	CP. Zama	Street/Per. Ltg.	54	0	$10,800	$0		105,482	0	360	0	$13,713	$10,800	0.79	10.31
Utility	SDHA	Street Ltg	24	0	$4,800	$0		39,947	0	136	0	$5,193	$4,800	0.92	8.79
S-322	CP. Zama	Band Trg. Fac.	7	23	$1,508	$12,816		53,263	4,346	785	8	$11,040	$14,324	1.30	7.72
S-134	CP. Zama	Steam Plant	24	64	$6,608	$33,128		16,871	30,821	4,332	10	$22,346	$39,736	1.78	7.18
S-117	SDHA	Theater	7	12	$1,508	$6,278		25,037	1,765	330	8	$4,976	$7,786	1.56	6.29
S-379	CP. Zama	Exch. Svc. Outlet	7	12	$1,508	$6,278		26,498	1,545	305	8	$4,962	$7,786	1.57	6.14
P-107	SDHA	Child Spt. Ctr.	11	18	$3,813	$8,977		48,178	1,992	441	8	$8,195	$12,790	1.56	5.96
P-333	CP. Zama	Enl. Mess	12	22	$2,506	$11,449		50,761	1,987	449	12	$8,568	$13,955	1.63	5.68
S-539-1	SDHA	Elementary Sch.	10	14	$2,217	$7,016		26,316	1,940	359	8	$5,304	$9,233	1.74	5.68
S-108	SDHA	Consol. Club	7	12	$1,508	$6,278		14,298	1,683	282	8	$3,504	$7,786	2.22	4.70
P-704	CP. Zama	Health Clinic	23	35	$5,038	$17,824		54,356	3,668	694	20	$10,678	$22,862	2.14	4.57
P-913	CP. Zama	High School	60	60	$12,356	$27,455		78,586	5,061	970	184	$16,826	$39,811	2.37	4.08
# -	CP. Zama	Remote Zone Temp	22	53	$4,416	$25,199	$165,816	0	44,434	6,163	0	$41,230	$195,431	4.74	3.88
#S-406	CP. Zama	Remote Elect. Eq.	10	22	$1,996	$11,294		45,971	0	157	16	$6,147	$13,290	2.16	3.77
#T-315	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		24,320	0	83	6	$3,224	$7,276	2.26	3.61
S-505	CP. Zama	Theater	39	43	$9,002	$21,530	$2,665	49,246	4,741	826	64	$11,467	$33,197	2.90	3.51
#S-346	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		23,123	0	78	8	$3,054	$7,276	2.38	3.42
S-500	CP. Zama	Chapel	21	31	$4,524	$19,974		59,431	1,315	385	16	$9,113	$24,498	2.69	3.28
P-104	CP. Zama	500 MI Grp.	22	39	$4,594	$18,195	$2,870	25,102	1,951	356	32	$5,406	$25,659	4.75	2.09
P-104	SDHA	Commissary	36	52	$9,132	$26,408		62,008	175	236	32	$8,556	$35,540	4.15	1.99
P-1042	CP. Zama	Vet. Fac.	13	40	$2,930	$19,456		18,936	855	183	10	$3,359	$22,386	6.66	1.41
P-337	SDHA	Youth Ctr.	10	22	$2,099	$10,334	$1,025	11,872	240	74	24	$2,016	$13,458	6.68	1.32
#S-643	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		7,293	0	25	6	$1,015	$7,276	7.17	1.14
#S-270	CP. Zama	Remote Elect. Eq.	10	22	$1,996	$10,938		12,025	0	41	12	$1,687	$12,934	7.67	1.07

PAST ECOs FROM FY82 EEAP STUDY WHICH ARE RELATED TO EMCS.

TABLE ES-10 (CONT'D)
BUILDING HARDWARE COSTS, ENERGY SAVINGS, SIMPLE PAYBACK AND SIR
TOTAL

BLDG. #	LOCATION	USE	INPUT/OUTPUT POINT COUNT		COSTS			SAVINGS				VALUE OF SVGS	INVEST-MENT TOTAL	SIMPLE PAY-BACK	SIR
					EMCS HARDWARE INSTRUMENT/CNT'RL		MODS TO EXSTG SYSTEMS								
			DIGITAL	ANALOG	DIGITAL	ANALOG		KWH	GALS/YR	MBH	M/H				
*S-453	CP. Zama	Consol. Club	56	81	$12,064	$40,581		60,878	1,562	424	64	$10,029	$52,645	5.25	0.98
*S-671	CP. Zama	Remote Elect. Eq.	10	23	$1,996	$11,747		11,470	0	39	14	$1,631	$13,743	8.43	0.97
S-113	SDHA	Deli/Laundry PU	11	23	$2,297	$11,414	$1,230	4,741	531	90	28	$1,400	$14,941	10.67	0.95
*S-120	CP. Zama	Remote Elect. Eq.	5	12	$998	$6,278		5,973	0	20	6	$824	$7,276	8.83	0.93
S-533	CP. Zama	Rec. Ctr.	9	19	$1,901	$8,845	$820	8,199	0	28	20	$1,274	$11,566	9.08	0.91
P-332	CP. Zama	Enl. Bks.	87	171	$17,464	$79,798		54,080	1,189	349	164	$9,839	$97,262	9.89	0.89
*S-316	CP. Zama	Remote Elect. Eq.	7	15	$1,390	$8,464	$1,025	8,106	0	28	10	$1,171	$10,879	9.29	0.88
P-450	CP. Zama	Post Office	27	55	$5,469	$26,007	$3,690	18,419	800	174	8	$3,220	$35,166	10.92	0.85
P-402	CP. Zama	ACS	18	28	$4,024	$15,859	$2,255	11,276	382	92	8	$1,904	$22,138	11.63	0.78
GRAND TOTALS			781	1242	$172,051	$622,305	$185,278	1,276,225	323,665	49,247	884	$432,116	$979,634		

* PAST ECOs FROM FY82 EEAP STUDY WHICH ARE RELATED TO EMCS.

*To be demolished in 1995.

b. Dependent High School, Building No. P-912, Camp Zama.

(1) Replace Lighting (Install Energy Efficient Lamps, More Efficient Lighting Sources, and Reduce Lighting Levels). Programmed Year Cost: $980.14. Simple Payback: 0.67, 1.31, 0.24, 1.95 years, respectively. SIR: 16.40, 8.34, 27.59, and 5.65 respectively.

(2) Add an Economizer Cycle. Programmed Year Cost: $6,336.14. Simple Payback: 6.44 Years. SIR: 1.24.

(3) Insulate Electric Hot Water Heater. Programmed Year Cost: $19.47. Simple Payback: 0.52 years. SIR: 19.64.

(4) Install Self-Closing Faucets on Lavatories. Programmed Year Cost: $914.48. Simple Payback: 3.18 years. SIR: 3.21.

c. Dependent High School, Building No. P-913, Camp Zama.

(1) Replace Lighting (Reduce Lighting Levels, Install Energy Efficient Lamps, and Replace Incandescent Lighting). Programmed Year Cost: $4,764.22. Simple Payback: 1.47, 0.67, and 1.30 years, respectively. SIR: 7.47, 16.37, and 8.36 respectively.

(2) Add an Economizer Cycle, Building P-913, Camp Zama. Programmed Year Cost: $25,648.32. Simple Payback: 2.80 Years. SIR: 2.85

(3) Install Time Clock on DHW Heater. Programmed Year Cost: $775.89. Simple Payback: 1.36 years. SIR: 7.52.

(4) Insulate Electric Hot Water Heater. Programmed Year Cost: $70.80. Simple Payback: 0.51 years. SIR: 21.44.

(5) Install Self-Closing Faucets on Lavatories. Programmed Year Cost: $1,828.96. Simple Payback: 3.19 years. SIR: 3.21.

(6) Change to High Efficiency Motors. Programmed Year Cost: $876.98. Simple Payback: 4.67 years. SIR: 2.19.

d. Refuse Incinerator (Heat Recovery) Plant, Building No. P-1024-1, Camp Zama.

(1) Modify Incinerator Operating Hours. Programmed Year Cost: $0.00. Simple Payback: 0 years. SIR: Infinity.

(2) Reset PHE Controls (Modify and Revise the Plate Heat Exchanger Controls). Programmed Year Cost: $41.60. Simple Payback: 0.01 years. SIR: 1,256.41.

(3) Heat Recovery System (Revise Incinerator Controls), Building No. P-1024-1, Camp Zama. Programmed Year Cost: $1,560.78. Simple Payback: 2.91 Years. SIR: 6.22.

(4) Install Time Clock (Stop the DHW Circulation Pumps During High Use Periods). Programmed Year Cost: $97.18. Simple Payback: 0.05 years. SIR: 200.50.

(5) ADDN Heat Recovery (Use Heat Recovery for Heating Hot Water (HHW)). Programmed Year Cost: $48,795.60. Simple Payback: 18.47 years. SIR: 1.15.

e. Re-evaluated FY82 EEAP Study ECO. Install Ceiling Insulation, (Family Housing), Sagami General Depot. Programmed Year Cost: $24,319.08. Simple Payback: 11.69 years. SIR: 1.06.

f. Re-evaluated FY82 EEAP Study ECO. Install Ceiling Insulation, Various Buildings (S-106, S-112, S-113, S-120, S-160, S-262, S-300, S-722, S-731, and S-996), Camp Zama. Programmed Year Cost: $56,822.92. Simple Payback: 7.23 years. SIR: 1.73.

8.4 POTENTIAL ENERGY AND COST SAVINGS

8.4.1 Camp Zama.

Energy savings from ECOs amount to 2,182.83 MBtu and from the EMCS the savings amount to 29,673.03 MBtu which represents 8.97% of the current consumption of 355,002.3 MBtu for Camp Zama. Cost savings are $293,670.65 of which $6,843.20 is from EMCS labor savings.

8.4.2 Sagamihara Dependent Housing Area (SDHA)

Energy savings from ECOs amount to 146.84 MBtu and from the EMCS the savings amount to 11,621.70 MBtu which represents 8.07% of the current consumption of 145,837.2 MBtu for SDHA. Cost savings are $99,936.36 of which $1,476.80 is from EMCS labor savings.

8.4.3 FY82 Energy Engineering Analysis Program (EEAP)

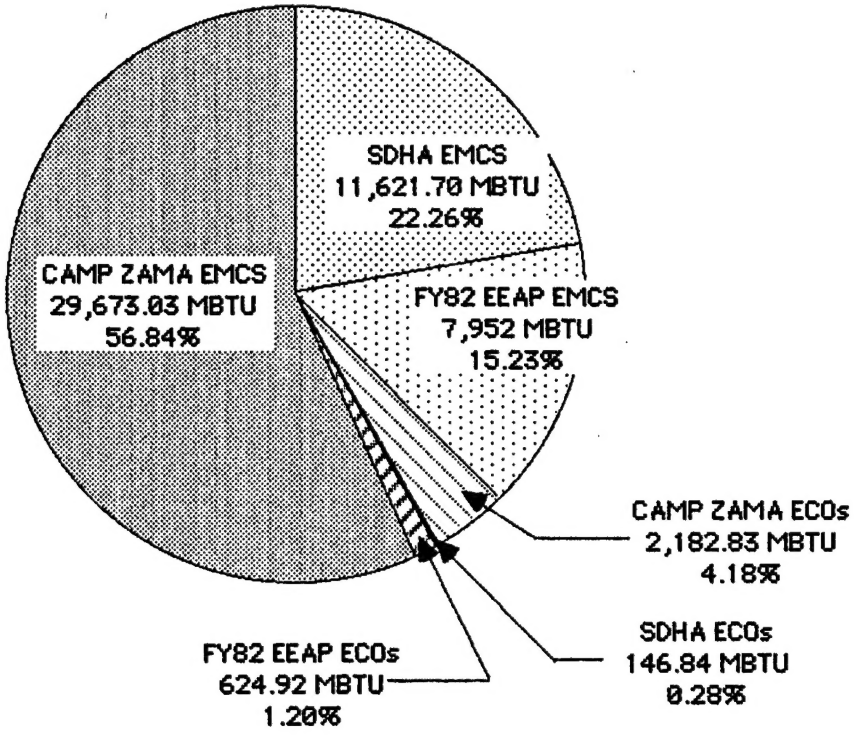
Energy savings from FY82 EEAP ECOs amount to 624.92 MBtu and from the FY82 EEAP ECOs related to EMCS the savings amount to 7,952.0 MBtu. Cost savings are $84,860.42 of which $873.60 is from EMCS labor savings.

8.4.4 Camp Zama/SDHA/FY82 EEAP

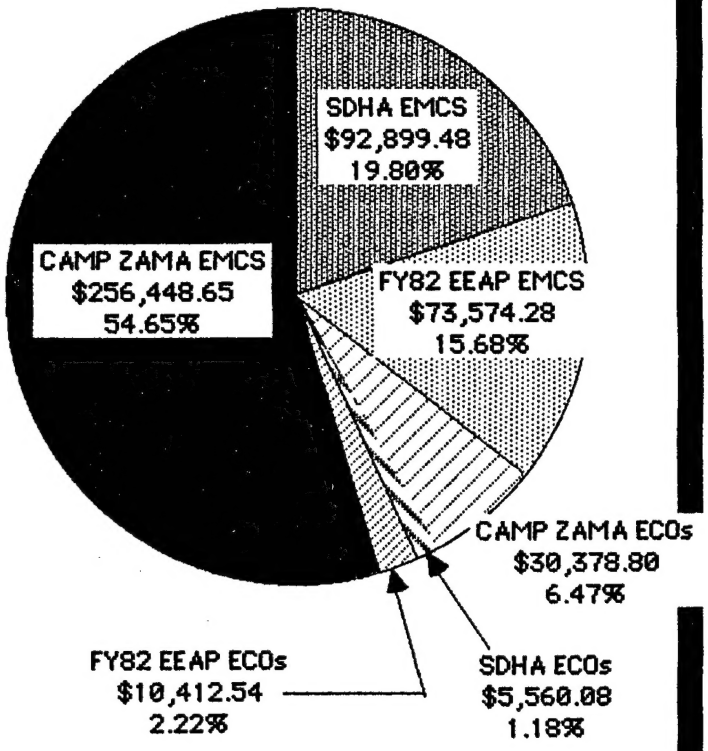
Energy savings from ECOs amount to 2,954.59 MBtu and from the EMCS the savings amount to 49,246.75 MBtu. Cost savings are $478,467.43 of which $9,193.60 is from EMCS labor savings. See Chart ES-3 entitled ECOs/EMCS Energy and Cost Savings on next page.

ECOs/EMCS
ENERGY AND COST SAVINGS

MBTU SAVINGS
52,201.34 MBtu



DOLLAR SAVINGS
$469,273.83



NOTE: $9,193.60 LABOR SAVINGS NOT INCLUDED IN CHART OR TOTAL SAVINGS

CHART ES-3